

CONDITIONS OF TERTIARY SEDIMENTATION IN SOUTHERN AUSTRALIA

By MARTIN F. GLAESSNER *

[Read 13 November 1952]

551.3.051 (94-13)

SUMMARY

Tertiary sedimentation in southern Australia begins generally with paralic deposits (brackish, lignitiferous, intermittently marine), followed in some areas by an Upper Eocene marine ingression. This is widespread in South Australia, possibly extending to Western Australia, but limited in Victoria. There is evidence of a Late Eocene and Early Oligocene second paralic phase. This is followed by important Upper Oligocene to Lower Miocene transgressions. The Upper Miocene was a period of regression and faulting. The Lower Pliocene transgression which followed was more extensive in Western Victoria than in South Australia.

INTRODUCTION

Until recently it was thought that the sequence of Tertiary strata throughout South Australia and the Murray Basin consisted of a lignitic, largely terrestrial formation of Oligocene age at the base, followed by Miocene, mostly in polyzoal limestone facies, overlain with slight local unconformity by Lower or Upper Pliocene sands or shell beds. The fallacy of this interpretation was first demonstrated by Parr who found *Hantkenina* of Upper Eocene age together with other significant elements of the *Hantkenina*-fauna described by him previously from the Otway coast in Victoria, in what was then believed to be the base of the marine Miocene at Aldinga Bay. Unfortunately, Parr died before he could complete his investigations and publish the results. In 1950 it was decided by the writer, in consultation with Professor Sir Douglas Mawson who had advocated, initiated and sponsored palaeontological investigations in the critical areas for many years, to make the stratigraphy and palaeontology of the Tertiary deposits of South Australia and adjoining areas the subject of a major research project. Its first stage was to be the detailed mapping of critical sections so that samples for micropalaeontological investigation and specimens of the megascopic fauna could be taken from strictly defined horizons and so their exact stratigraphic ranges determined. This was to be supplemented by a similarly detailed study of well-selected samples from deep bores which were very generously made available by the South Australian Mines Department to the writer in his capacity as Honorary Consultant to the Department. Concurrently a critical systematic study of significant fossils from these sections was to be undertaken in order to give a clearly defined meaning and status to names of fossils found to be of importance in these studies. This work is being carried out by research students at the University of Adelaide, under the writer's direction, with financial assistance from the University's research funds. It is desirable to accompany with a progress report on the whole project the publication of the first paper describing results of this work (Reynolds 1953). As stratigraphic field work must precede descriptive palaeontological studies in order to base selection of samples and species for description on known field relations, more precise palaeontological age determinations will constitute the final rather than the initial stage of the project. The present progress report deals therefore with the nature of the deposits in their observed sequence rather than with their exact ages.

*University of Adelaide.

EARLY EOCENE PARALIC FACIES

The term paralic (for a recent definition see Tercier 1939, p. 88) denotes sedimentation in a changing and alternating marine and non-marine environment of coastal swamps, lagoons, estuaries or deltas. In the Aldinga Bay section Tertiary sedimentation commences with the non-marine North Maslin Sands. These sands which contain a flora thought by Chapman (1935) to be Lower Oligocene, are well below the *Hantkenina* zone and are therefore not likely to be younger than early Eocene. The overlying South Maslin Sands which are glauconitic and at least intermittently marine are regarded by Reynolds as formed in the marine part of a delta. Both formations appear in the adjacent section at Christie's Beach and on their boundary laterilization indicating emergence is noticeable. This section was mapped and will be described by Miss M. Wade. Recent studies by B. Daily indicate that the Noarlunga lignites correspond to the North Maslin Sands and a deep bore in the Willunga Basin which is now under examination has also reached lignitic sands below a bed with *Hantkenina*.

In Victoria, the *Hantkenina*-fauna occurs in the Cape Otway area (Aire Coast). Recent field investigations by Raggatt and Crespin (1952) have led to the conclusion that equivalents of the "Anglesean" are found below the *Hantkenina*-zone of Brown's Creek instead of above as previously assumed (and as shown in Glaessner 1951, p. 274); that the "Anglesean" east of the Otways (now named Demon's Bluff Formation) overlies the "unfossiliferous" Boonah Sandstones and the Eastern View Coal Measures; and that the equivalents of that Formation west of the Otways overlie the Pebble Point Beds and thus are part of the Wangerrip Formation. Baker (1950) described the Wangerrip Formation as "littoral, shallow water deposits, such as conglomerates, coarse grits, sandstones (some gritty, some carbonaceous and some iron stained) and ironstones that are overlain by, and in part interbedded with, clays containing gypsum and copiapite." Fossils occur only in bands and lenses and some of these beds contain only carbonaceous material and fragments of wood.

The fauna of the Pebble Point Beds indicates early Eocene (or possibly Paleocene) age. It was found recently in similar strata near Casterton, 120 miles northwest of the first locality (Kenley 1952). It is likely that at least some of these deposits are time equivalents of the pre-Upper Eocene paralic strata of South Australia though there is no direct palaeontological evidence for their correlation. The poor fauna and peculiar lithology of the Anglesea and Addiscot Members of the Demon's Bluff Formation indicate paralic environment.

LATE EOCENE MARINE FACIES AND EQUIVALENTS

The South Maslin Sand is overlain with a slight erosional disconformity by the Tortachilla Limestone which grades upward into the "transitional" basal beds of the Blanche Point Marl with *Hantkenina alabamensis compressa* Parr and other Eocene fossils. Particularly important restricted species of the Tortachilla fauna are *Australanthus longianus* (Gregory) and *Aturia clarkei attenuata* Teichert and Cotton. *Notostrea lubra* Finlay occurs abundantly in the basal bed of the "Banded Marl" Member of the Blanche Point Marls, where siliceous sponges also become abundant and conspicuous. This distinctive shallow-water marine interval is equally well developed in the Willunga and Noarlunga Basins. Foraminiferal species such as *Asterigerina adelaidensis* (Howchin) which occur in it permit us to trace it into the Adelaide Basin, where this species was first described (as *Truncatulina margaritifera* var. *adelaidensis*) from 195-218 ft. in the Kent Town bore (Howchin 1891). It also occurs in the Croydon bore at

1,681 ft. This correlation explains the much-discussed difference in thickness between the pre-Pliocene fossiliferous sediments in the Kent Town and Croydon bores (which are separated by the Para Fault) as the result of pre-Pliocene erosion of at least 800 feet of strata from the upthrow side of the fault.

The Late Eocene marine formation is apparently also represented at Kingscote, Kangaroo Island, where *Australanthus longianus* occurs and in the lower Nullarbor (Eucla) limestones where D. King collected *Notostrea lubra* and *Australanthus longianus* (see King 1950; specimens in the collection of the Geology Department, University of Adelaide). It is suggested that the Planagenet Beds of Western Australia, with *Aturia clarkei* Teichert and a rich fauna of sponges are probably about the same age. They had been placed in the Miocene by Chapman and Crespin (1934). The first discovery of Eocene in Australia (apart from the tropical and Indo-Pacific faunas of the North-west) was the result of Parr's brilliant analysis of the fauna of small foraminifera from the King's Park bore in Perth (1938). This was followed by Parr's discovery of *Hantkenina alabamensis compressa* in the Otways area (Parr 1947). Since then, Raggatt and Crespin (1952) have announced in a preliminary note "the discovery of *Hantkenina alabamensis* at the top of the Jan Juc Formation at Bird Rock", the type locality of the Janjukian. The writer is not prepared to accept this statement as evidence of Upper Eocene age of the Janjukian (as restricted by Raggatt and Crespin) because a critical study of a considerable number of samples from the same locality has shown that the foraminiferal assemblage differs significantly from that of the other known Eocene localities with *Hantkenina alabamensis compressa*. No further specimens of this species or of other restricted species usually associated with it have been found at Bird Rock. The composition of the fauna suggests a younger age than the *Hantkenina* faunal zone. Whether this anomalous reported occurrence indicates that the biozone of this *Hantkenina* extended beyond the *Hantkenina* faunal zone (and beyond the limits of the biozone of the genus elsewhere), whether the specimens are derived from older strata, or whether some other explanation is possible cannot be decided until the faunas are described. The typical Brown's Creek fauna has not been found east of the Otways.

LATE EOCENE AND EARLY OLIGOCENE PARALIC FACIES

In the Maslin Bay-Aldinga Bay standard section the "Banded Marl" Member of the Blanche Point Formation grades upward into the "Soft Marl" Member. Both together represent the well-known *Turritella* beds. Their upper part was described by Tate in his account of the Croydon bore as "bituminous" and Reynolds mentions in his description of Aldinga Bay their dark colour which "may be due partly to the presence of organic matter." There is evidence from bores in the Willunga Basin, which is being examined by G. Woodard, of the association of lignites with *Turritella* marls above *Hantkenina*-bearing beds. Reynolds describes the Chinaman's Gully Beds as a thin non-marine formation overlying the Blanche Point "Soft Marls." They occur in a corresponding position in the Noarlunga basin at the mouth of the Onkaparinga River. This evidence indicates the existence, above the Upper Eocene marine sediments, of another group of paralic deposits. Faunal studies are not sufficiently advanced to place exactly the boundary between Eocene and Oligocene in relation to these deposits and indeed it is questionable whether this boundary can be fixed by objective criteria in the absence of such world-wide markers as *Discocyclina* or *Nummulites*. As these paralic sediments are well above the *Hantkenina* beds and are overlain by a thick marine formation grading upwards into Lower Miocene, they are likely to represent the lower part of the Oligocene. The discovery of a second paralic

phase of probably early Oligocene age in South Australia suggests that where the *Hantkenina* fauna is absent, the paralic facies may extend from the early Eocene to the early Oligocene. Raggatt and Crespin (1952, p. 143) recognised erosional disconformities between the Angahook Member of the Demon's Bluff Formation and the Jan Juc Formation but considered their time significance as small. At Airey's Inlet the erosional interval between the basalts of the Angahook Member and the overlying Torquay Group is obvious. The "ligneous sands and clays" of Dartmoor which are overlain by "Janjukian with *Victoriella*" (Gloe 1947) should be carefully examined for evidence which may prove whether they represent the early Eocene or the early Oligocene or both paralic phases. Their equivalents in the south-east of South Australia are now being examined from this point of view.

LATE OLIGOCENE AND LOWER MIOCENE MARINE FACIES

The upper paralic deposits of the Willunga Basin and their equivalents in the Noarlunga Basin are overlain by polyzoal limestones and calcareous sands (calcareenites). Their fauna of mollusca, echinoids and foraminifera differs strikingly from that of the Tortachilla polyzoal limestones and their equivalents. The polyzoal Port Willunga Beds reach thicknesses of nearly 300 feet in the Willunga Basin and over 400 feet in the Adelaide Basin (Croydon bore). In the Myponga Basin these polyzoal limestones and interbedded sandy clays are also about 400 feet thick, as proved by the Myponga bore which is being examined by Miss M. Wade. A Lower Miocene *Lepidocyclina* fauna corresponding to that of the Batesford Limestone was found in a sample from the upper third of this formation. In the Willunga Basin the lower part of the Port Willunga Beds contains *Sherbornina* and *Gümbelina* and in the Adelaide Basin (Miles 1952) Miss Crespin found the *Sherbornina*-fauna overlain by the Lower Miocene *Austrotrillina*-fauna. These beds represent the Upper Oligocene and Lower Miocene. The Port Willunga beds resemble in lithology and fauna the Gambier Limestone and also the Torquay Group (Janjukian *sensu lato*). This has been observed also by earlier authors. In South Australia, disconformable or unconformable relations seem to be the rule at the base of these marine deposits. In the Willunga and Noarlunga Basins they rest on non-marine sediments. South of Sellick's Beach they overlie transgressively with a basal breccia the Cambrian strata of the Willunga scarp. This is, therefore, basically not a Late or post-Tertiary fault scarp but an old shoreline, probably representing an earlier fault-line scarp, over which the Oligocene sea transgressed. In Late Tertiary (possibly Late Miocene) time a steep flexure developed over it, as described by Howchin (1911). In the Myponga basin the same polyzoal limestones rest on pre-Cambrian and on the overlying Permian glacial deposits. On the eastern flank of the Mount Lofty Ranges post-eocene Tertiary limestones overlie granites or slates from which they are locally separated (near Strathalbyn) by a thin pebble bed. I am indebted to Mr. R. C. Sprigg, of the South Australian Mines Department, for an opportunity to study Knight's Quarry, six miles north-east of Mt. Gambier where the Gambier polyzoal limestone overlies a non-marine formation with angular unconformity. The base of the limestone is marked here by a nodule bed. Such unconformable relations at the base of the Upper Oligocene to Lower Miocene marine deposits seem to be of regional importance. In the Nullarbor Plains the Lower Miocene limestone with *Austrotrillina* rests on a paralic sequence of Lower Tertiary strata near Pidinga (King 1950) but apparently it overlies directly the Eocene limestones in the caves described earlier by King (1951). In Victoria, Baker (1944) found a nodule bed containing derived Eocene fossils near the mouth of the Gellibrand River, forming the

base of beds with "Janjukian" foraminifera grading upwards into Lower Miocene ("Batesfordian") with *Orbulina*. This Late Oligocene and Lower Miocene transgression was apparently not strictly contemporaneous throughout southern Australia and its base should not be taken as a time-stratigraphic horizon. The underlying Lower Tertiary sediments are not everywhere of the same age. The transgression was preceded in some areas by uplift and erosion while in others there is no evidence of earlier open sea sedimentation. In particular, the Late Eocene marine sediments do not appear to have extended over the Mount Lofty Ranges and in the Torquay-Port Phillip area the early Tertiary paralic sedimentation was not interrupted by pronounced marine phases.

LATE TERTIARY SEDIMENTATION

The Late Miocene seems to have been a period of regression, uplift and faulting. Its sediments are not known in South Australia. From Adelaide to Sellick's Beach the Pre-Cambrian and Permian, and the various members of the Tertiary sequence, are unconformably overlain by Pliocene sands, clays and limestones. Along a narrow coastal fringe these are intermittently fossiliferous but similar unfossiliferous and probably non-marine sediments extend a few miles inland. As the Pliocene strata are about 300 feet thick in the Adelaide Basin they cannot be expected to be confined to a thin layer at a constant level on the faulted blocks south of Adelaide. Similar deposits, some of them fossiliferous, are indeed found up to 300 feet above sea level and there seems to be no good reason to consider them as post-Pliocene on account of their elevated position as has been suggested.

In Western Victoria Lower Pliocene ("Kalinman") marine faunas are known from Hamilton and from bores in the Mallee and Wimmera. The Pliocene strata seem to rest on Lower Miocene or older deposits. Late and Post-Tertiary erosion has removed the early Pliocene from the coastal areas.

CONCLUSION

A large part of southern Australia was during Tertiary time a "mobile shelf" area. Conglomerates are generally confined to the earliest and latest stages of sedimentation, other sediments are dominantly fine-grained and detrital, with polyzoal limestones widely developed at times of widespread transgression. There is evidence of two paralic and two marine periods (as shown by Reynolds in the Maslin Bay-Aldinga Bay section). Intermittently marine and brackish or lignitic strata may therefore be followed either by late Eocene or by late Oligocene to Miocene marine deposits.

REFERENCES

- BAKER, G. 1950 Geology and Physiography of the Moonlight Head District, Victoria. Proc. Roy. Soc. Vict., 60, n.s., 17-42
- CHAPMAN, F., 1935 Plant remains of Lower Oligocene age from near Blanche Point, Aldinga, South Australia. Trans. Roy. Soc. S. Aust., 59, 237-240
- CHAPMAN, F., and CRESPIN, I., 1934 The Palaeontology of the Plantagenet beds of Western Australia. Journ. Roy. Soc. W. Aust., 20, 103-136
- GLAESSNER, M. F. 1951 Three foraminiferal zones in the Tertiary of Australia. Geol. Mag., 88, 273-283
- GLOE, C. 1947 The underground water resources of Victoria. State Rivers and Water Supply Comm., Melbourne, 158 pp.
- HOWCHIN, W. 1891 The foraminifera of the Older Tertiary (No. 2, Kent Town Bore, Adelaide). Trans. Roy. Soc. S. Aust., 14, 350-354

- HOWCHIN, W. 1911 Description of a disturbed area of Cainozoic rocks in South Australia. Trans. Roy. Soc. S. Aust., 35, 47-59
- KENLEY, P. 1952 Marine Eocene sediments near Casterton, Victoria. Aust. Journ. Sci., 14, 91-92
- KING, D. 1950 Geological notes on the Nullarbor cavernous limestone. Trans. Roy. Soc. S. Aust., 73, 52-58
- KING, D. 1951 Geology of the Pidinga area. Trans. Roy. Soc. S. Aust., 74, 25-43
- MILES, K. 1952 Geology and underground water resources of the Adelaide Plains area. Dept. Mines Geol. Survey, S. Aust., Bull. 27
- PARR, W. J. 1938 Upper Eocene foraminifera from deep borings in King's Park, Perth, Western Australia. Journ. Roy. Soc. W. Aust., 24, 69-101
- PARR, W. J. 1947 An Australian record of the foraminiferal genus *Hantkenina*. Proc. Roy. Soc. Vict., 58, n.s., 45-47
- RAGGATT, H. G., and CRESPIN, I. 1952 Geology of Tertiary rocks between Torquay and Eastern View, Victoria. Aust. Journ. Sci., 14, 143-147
- REYNOLDS, M. A. 1953 The Cainozoic Succession of Maslin and Aldinga Bays, South Australia. Trans. Roy. Soc. S. Aust., 76
- TERCIER, J. 1939 Dépôts marins actuels et séries géologiques. Eclogae Geol. Helvet., 32, 47-100